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# TECHNOLOGY AND URBAN MANAGEMENT

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## I. SETTING AND PROJECT OBJECTIVES

The remarkable pace of discovery and invention that marks the second half of this century is rapidly changing the very structure of contemporary urban society and of the city. The changes that are now underway are likely to be far more dramatic than those of the last century, in part because the federal government is currently sponsoring so large a scientific and technological effort.

During the past century, the first major federal research and development effort turned a family-based, handicraft agriculture into an incredibly productive mechanized industry. As one consequence, the farmlands of the nation have been largely depopulated, contributing to the unprecedented expansion of the metropolitan centers. As a further consequence, such nonagricultural commodities as the national ideologies, the styles-of-life, and even the distribution of political power that marked the agrarian stage of American development were replaced by the now-familiar ones that mark the current urban stage. The changes came quickly, accelerated by the developments in metallurgy, electric-power generation, mechanized transport, and the larger wave of discoveries and inventions that underlay industrialization and spawned the age of cities. The changes came in ways that none of the agronomists, geneticists, chemists, physicists, and engineers who triggered it all could ever have anticipated.

Now we are in the midst of what is surely a new golden age of discovery and invention. A new chain of events is being set off, with the prospect that the familiar patterns of industrial-urban society will soon be replaced by yet unseen ones and the problems of adaptation will have to be dealt with. Effective adaptation will require a kind of careful forecasting with which we have had little experience. We are already aware of some of the consequences of the unlocked atom, but those that might come from the unlocked genetic code are still unclear. We are already reaping many of the benefits of the computer in improved

managerial capabilities and accelerated research schedules, but the long-term consequences of the computer are still only vaguely predicted.

The consequences of space exploration have been felt most directly in their city-building effects at those locations where NASA has placed its installations and where its contractors have located their plants. But the more subtle consequences of the space program for social change are only now becoming dimly visible — in the current theological reappraisals, in the dramatic new prospects for world-wide communications, in the enlarged life-space opened to this generation of youths, in the changes within the economy's product mix, and in the technological scale of commercial enterprises.

It is, of course, no surprise that the effects of the new findings of science and the new technological innovations should be localized in our cities, for they impinge on a society that is fundamentally urban in its social organization and in its localization patterns. By now, it is no surprise that these effects are being felt most strongly in the central cities of our metropolitan areas, for it is there that adaptation to change is most difficult.

It is now apparent that many of the central cities' problems can be traced directly to the economic and social changes that were triggered by the recent discoveries of science and the recent developments in technology. We are already beginning to feel the effects of the space sciences and space explorations programs.

The declining proportion of total employment contributed by manufacturing and unskilled occupations and the rise of the service occupations — particularly the highly skilled, professional jobs that require college training — signal the fundamental changes underway. The effects impinge with emphasis upon the central cities, for the expansion of the technologically advanced industries is occurring in the suburbs.

The recent rural migrants — the people who are the least trained segment of the labor force and the least integrated into the highly technical society — are being concentrated in the central cities. As a result, newcomers' opportunities for employment, for skills

improvements, and for acculturation into modern society are declining. As a further result, the central cities exhibit high incidences of unemployment, economic dependency, physical and mental illness, and the full range of correlated social pathologies — high crime rates, high proportions of fatherless families, high incidences of drug addiction and alcoholism, and the rest of the too-familiar roster of conditions that now mark the central cities in this period of rapid technological development.

The wide disparities between the conditions of suburban residents and those of central city residents are confronting city managers with powerful imperatives to invent new ways of dealing with problems — indeed, to invent new ways of governing. This problem, combined with the further disparity between the rapid acceleration of knowledge and know-how and the declining quality of city life, had set the stage for the 1963 Dunsmuir House Conference in Oakland. At that time, Mr. James Webb of NASA, Dr. Clark Kerr of the University of California, Mr. Wayne Thompson, City Manager in Oakland, and Dr. Paul Ylvisaker of the Ford Foundation, joined forces to explore the opportunities that might be latent within the newly emerging technologies for dealing with the critical problems of the city. The conclusions of the Dunsmuir House Conference were persuasive.

The discussions did indeed reveal some potential applications of the new technologies for alleviating the urban problems they had helped to create. Also, the officials from the Berkeley Campus were further sensitized to the problems of their neighboring city, and they resolved to try to direct the interests of the powerful intellectual resources of the University to ward the unresolved difficulties faced by the city residents and the city officials. Like many of its sister universities, the Berkeley Campus had long ignored the developmental issues of its host cities, even though the university and its members have been intimately affected by local developmental conditions and the faculty and students have held many of the competencies that might have attacked those issues effectively.

The city of Oakland then invited personnel from NASA and the University at Berkeley to engage in a joint research-and-development effort, directed toward improvement of the city's problem-solving capabilities. City Manager Thompson offered the facilities of the city

government for an experimental laboratory where new approaches to the urban problem-solving efforts might be tested. The current Technology and Urban Management Project is the expression of this three-party resolution to re-direct contemporary science and technology back into the city problems they had contributed to.

The objectives of our current research are of these three types:

1. Technical assistance to the Oakland city government, drawing upon the capabilities of students and faculty members who are working directly with and for city officials.

2. Uncovering potential urban applications of space and other new technologies, and assisting the city in testing and installing them. Should we be successful, we expect that other cities will also adopt these applications, and we can thereby help generate a new industrial activity in the neglected urban-services field.

3. Simultaneous projects by each of the University researchers in his specialized theoretical or methodological interests. The usual series of monographs, doctoral dissertations, journal articles, and books are anticipated.

The research is organized in a series of subprojects, each directed by a member of the faculty, assisted by a group of graduate students. The individual subprojects are coherent research enterprises in themselves, but they are designed to reinforce each other, particularly in the later stages of the research.

## II. THE INDIVIDUAL STUDIES

### 1. OAKLAND BUDGET STUDIES

Professor Aaron Wildavsky, Chairman of the Department of Political Science, is conducting an intensive study of the budgetary processes of the Oakland city government with emphasis upon the roles of the budget as the key expression of policy and the key instrument for program planning. The purpose of this project is to assist the city of Oakland in the allocation of its budgetary resources. To accomplish this goal, how the budgetary process operates now in Oakland must first be understood; then suggestions for change will be formulated.

The research schedule is divided into essentially two time periods. The first year is being devoted to interviews and the collection of data that will provide an understanding of present budgetary practices. The second year will be devoted to formulating recommendations for change, based upon our knowledge of past practices, and to conducting various assistance studies to formulate alternative procedures for the future.

The first year's work is proceeding on schedule and in accordance with Professor Wildavsky's original plan. A talented graduate student in the Department of Political Science, Arnold Meltsner, is serving as a special assistant to the City Manager. He is not only monitoring activities now underway, but he is also actively suggesting things that might be done to assist the City and the City Manager during this interim period. Through a series of documentary researches, the group has arrived at an overall description of the Oakland budgetary process — it is constrained severely by a variety of constitutional rules and practices, such that the budget must be balanced every year and a cash reserve must be maintained to meet obligations as they come due. The result is a series of strategies to assure that the City always has a certain amount of money on hand. A variety of irritating practices and other difficulties can be traced to these essential conditions.

In addition to the work in the City Manager's office, Dr. Wildavsky's graduate assistants have initiated in-depth studies of important City activities. Warren Crowther has completed a great deal of work in a study of the police department that has provided a good understanding of the special budgetary arrangement for this department. A similar in-depth study of the Department of Human Resources, the agency that administers the City's widespread poverty programs has been carried out by Miss Judith May. Portia Shapiro is currently studying the Parks, Recreation, and City Planning departments, plus a variety of smaller agencies. Eric Sears is reviewing the activities within the Streets and Engineering Department and is extending earlier studies in the public-safety field. Because they have been impressed by the amount of information and the depth of understanding the project team has been accumulating, the Police Department and the Department of Human Resources have begun to press us for recommendations. The

program of analytic studies is not yet completed, however, and the group has been resisting these attempts to require premature advice. By the late spring or early summer, Dr. Wildavsky expects to be in a position to review and to evaluate the group's knowledge of existing processes; the project will then direct its efforts toward designing improved managerial budgeting procedures.

At this stage of the inquiry it appears that the City is lacking in certain talents that are essential for the analysis of these problems. Our proposals will not be helpful if they call for elaborate analytic techniques that cannot be carried out. We believe that we will be able to suggest a variety of simple studies and practices that will assist the City significantly. After initial improvement in the quality of personnel and in the information resources available, Oakland might be ready to undertake program budgeting and a variety of systems analyses that could further enhance its capacities for dealing with its problems.

The research team has received excellent cooperation from city agencies, whose officials have given a tremendous amount of time. They have been provided with confidential records and all other materials needed to conduct the studies. The officials of the City have been uncommonly receptive; they have been eager to explain their present thinking and practices, and they are eager to find ways to improve their present operations. While there are numerous and important constraints on the City's freedoms to cope with its difficult problems, the researchers believe that there is sufficient leeway to permit considerable improvements during the near future. During the course of the project's second year, a serious attempt will be made to help the City accomplish those improvements.

## 2. SYSTEMS ANALYSIS OF THE PROTECTIVE SERVICES

### a. The Fire Protection System

An analysis of the Oakland Fire Department was conducted by Professor Richard B. Hoffman, assisted by Stephen Coffin, doctoral candidate in mathematics, and Lee Wingerd, graduate student in management science. The primary objective of this study is the application of new technologies to an urban-protective services function.

An extensive literature search, interviews with the members of the Oakland Fire Department, interviews with industry and insurance officials, and conferences with fire department personnel in San Francisco, Los Angeles city, and Los Angeles county have contributed background material for the study.

The members of the study group have identified seven basic problem areas that have become the foci of our search for useful technological transfer:

1) Methods by which the relative frequency of fires may be reduced. These subsume fire-prevention activities, as presently constituted and reflected in enforcement of laws and regulations. But they would also include technologies not normally available to fire departments, owing to their technical or conceptual natures. We hope to be able to recommend changes in regulations and methods for securing compliance as well as changes in fire-deterring hardware.

2) Means used to detect destructive fires, to identify their location and nature, and rapidly to transmit this information to the members of the fire department and related agencies having responsibility for taking action.

3) Methods and procedures used for emergency, short-run (weekly to yearly), and longer-term allocation of the resources of groups engaged in fire prevention.

4) The devices, methods, and policies intended to protect the life, health, and safety of individuals from the hazards (including injury and harmful side-effects) of exposure to fire conditions, either as victims or as fire-fighters.

5) Operations and activities relating to the containment of fire. This problem involves developing tactical and strategic attack plans with reference to the size and deployment of fire-fighting forces.

6) Activities and resources required to extinguish an isolated or contained fire.

7) Methods and materials relating to the training of fire-suppression and fire-prevention forces.

On the basis of this breakdown the study group hypothesizes that system improvements will take two basic forms: (1) improving the performance characteristics of the existing system, and (2) changing the programs, methods, and techniques by which the system obtains results.

At an early stage in the study, several additional problems were recognized; and special programs were developed to focus on them. The problems and the research activities related to these problems are as follows:

1. The emergency communications system. At the suggestion of members of the Oakland Fire Department and the director of the Oakland Electrical Department, who is responsible for the communications system, Mr. Coffin has produced a detailed description of the fire department's emergency communication system.

Time is an essential factor in an attempt to minimize the cost of a fire. Flashover usually occurs in old frame buildings within seven or eight minutes after the start of the fire; once it occurs, there is little a fire department can do to save the building. Thus, a department has very little time in which to react to an alarm. This is especially true in Oakland, since approximately one minute elapses before the department receives an alarm once it has been sounded. We expect that some of the more important operational improvements in fire-department activities will be in the form of new techniques that reduce response time.

2. Implementation of proposals for technological transfer. Although much of their work to date has been of a consultative nature, the members of the study group are primarily researchers and not consultants. It is unlikely that the resources will be available for the group to stay with the Fire Department over the extended period during which implementation is to occur. We have therefore initiated a technological transfer task force composed of members of the TAUM project and the Oakland Fire Department. The task force has two major purposes. First, to provide a means by which the proposals for transfer of technology may be evaluated in terms of their cost and effectiveness. Second, to exploit the very considerable knowledge that

representatives of the Oakland Fire Department can contribute in evaluting proposals and to exploit their interest in field-testing technological improvements. Thus, when technological improvements are implemented, a Departmental team will be prepared to measure their effectiveness. Further, if the research team and the fire officials work hand-in-hand in introducing and evaluating possible technological innovations, necessary changes will be made with greater ease and enthusiasm. The jointly staffed technology-transfer task force has now selected a series of specific problems, whose solutions seem likely to yield a relatively high and immediate payoff. These have become the focus of our effort to evaluate the suggestions for technological transfer. The first two problem areas receiving detailed treatment are the communication and information-processing system of the department and the system of protective clothing and accompanying apparatus. The task force has outlined many deficiencies in these systems and is currently writing a set of generalized specifications for the removal of these deficiencies.

The co-chairmen of this group are Battalion Chief Clifton M. Basch of the Oakland Fire Department and Rae Archibald, a member of the TAUM research staff on technology transfer. Chief James Sweeney and First Assistant Thomas Harris, who have been serving as the Fire Department's liaison with the TAUM group, and Professor Hoffman serve as ex-officio members of the task force.

3. Allocation of departmental and related resources during emergencies. We realized early in the study that many of the improvements in the Department would depend critically upon a model for resource allocation. Discussions with Fire Department officials and an extensive literature search indicated that the conceptual basis for such a model does not exist. In an attempt to better understand and then to resolve the problem, Professor Hoffman has developed a stochastic model of fire damage as a function of time and of the contents, structure, and class of building. The team intends to base its recommendations for resource allocation on this model; the recommendations will pertain to station locations, manpower loading, tactical deployment, and emergency cover-in plans. (The objective of a cover-in plan is to relocate men

and equipment in a specific emergency situation so that all parts of the city will have equal coverage. Although its existing cover-in plans are good, the Department has no way of measuring how well it is meeting its objective.)

4. Departmental effectiveness. Professor Hoffman has prepared a number of models for making inter-city comparisons of fire department effectiveness. Measures of effectiveness are necessary to substantiate recommendations that the Fire Department receive financial support to obtain new hardware identified in the technological transfer studies. Since there are no such measures generally accepted at present, a sensitivity analysis has been run on the parameter of our models. When the analysis is completed, models will be selected to indicate where R & D efforts should be made and/or where the purchase of hardware is warranted.

b. The Police Protection System

This sub-project is under the direction of Professor Gordon Misner of the School of Criminology. During much of the first project-year Professor Misner was on assignment to a study of the Police and the Community for the President's Commission on Law Enforcement and the Administration of Justice. The start of our work with the Oakland Police Department was accordingly delayed. The Crime Commission study will provide some inputs to ours, however. The systems analysis of the Oakland police services will profit from comparison with the Crime Commission studies in Philadelphia and San Diego, and from the experience Professor Misner gained in administering large-scale research into the adminstrative procedures of central city police departments.

The systems analysis planned for the Oakland Police Department has been designed to focus upon key decisional areas in the Department and to give particular emphasis to those parts of the organization which are judged to be the most fruitful ones for the application of new technological advances. During the Fall, Professors Misner and Hoffman designed the necessary instruments for the analysis, as well as a detailed schedule for a twenty-eight week period of initial study. Two seminars

were held in which Misner and Hoffman outlined and discussed their design with other members of the TAUM staff.

In addition, Professors Churchman and Webber along with other project staff members held two conferences with officials of the Oakland Police Department, the City Manager, and other city officials, in order to discuss the project design, objectives, and related matters. As a result of these meetings, cordial relations have been established between key personnel of the research staff and concerned city officials. In addition, it has been decided to establish a system of periodic conferences with ranking police officials, the City Manager, and others. These conferences are designed not only to regularize communication between the various parties involved in the project, but also to provide the necessary vehicle for participation by high-ranking personnel.

In December, Mr. John A. Webster was added to the research staff. Mr. Webster, a doctoral student with the School of Criminology, and a retired Air Force Lieutenant Colonel, has a significant background in both civilian and military policing. Since his retirement from the Air Force, Mr. Webster has taught police administration at both New Mexico State University and the University of Southern California. In addition to Mr. Webster, the research staff has been supplemented by the consultation of Dr. Ernest Koenigsberg of the Matson Research Corporation. Dr. Koenigsberg's services will continue to be available to the project on a limited basis each month.

Because of the seasonal burdens placed upon municipal police personnel during the Christmas shopping season, intensive work with the Police Department was postponed until after January, 1967. In the interim, a literature search was undertaken for resources in the police administration field. This search is proving what the researchers had initially suspected—that the police-administration field has received very little attention from students of administration and operational analysis. The review of the literature is continuing with the expectation that the new-found interest in crime prevention will now be generating a lively field of research in this field.

Detailed work with the Police Department began in January, 1967. Members of the research staff have conducted intensive interviews with the Chief of Police and his principal assistants. When these interviews have been completed, a preliminary systems description will be prepared. Shortly thereafter, members of the staff and the leadership of the Police Department will cooperatively endeavor to pinpoint those parts of the urban security function which appear to hold the greatest promise for the application of new technology. Members of the staff will then formalize their systems analysis.

The planned systems analysis of the Police Department contemplates the accumulation of data through the vehicle of intensive interviews with key decision-makers in the Department. These interviews will focus upon deriving answers to questions falling within the following seven broad categories: Function, Activity, Experiential Background, Information Flow, Mission Identification, Training and Promotion, Organizational Controls and Standards.

To assist not only in the systems analysis but also in detailing information flow patterns within the Department, each subject interviewed is being asked to make available hard-copy examples of forms and reports he regularly receives, prepares, or processes.

The design of the research takes into account the intuitive feelings of the researchers that specific portions of the Police Department organization will be more fruitful ones for the potential application of new technology. The design also provides for the meaningful cooperation and participation of the Department in the endeavor. Techniques developed by Professor Hoffman in the study of the Fire Department are being used to their greatest possible extent. All persons contacted in the Police Department are being encouraged to volunteer any technological "ideas" they have in relationship to either their own duties or to the over-all mission of the urban-security function.

The research design also accomodates the need both for periodic review of the technology transfer suggestions and for periodic assessment of the over all study of the Police Department. In addition to scheduled meetings between research personnel and ranking members

of the Department, it is contemplated that contacts between the researchers and certain lower-echelon police personnel will become regularized hopefully in a series of seminars. The design also contemplates periodic inquiry into system improvements, accomplished in cooperation with the researchers involved in the study of Technological Transference.

## 3. THE ECONOMICS OF SOCIAL SERVICES SUPPLY

In the initial proposal it was suggested that this section would have as its over all objective the analysis of methods for the evaluation and improvement of the supply of municipal services. We hoped to be able to utilize ideas and methods deriving from the Federal Planning, Programming, and Budgeting System (PPBS) with special reference to problems in transferring this technique to the local scale. Three immediate objectives were established: (1) a careful investigation of the present state of knowledge of PPBS methods; (2) an analysis of the general problems likely to arise in the transfer of PPBS methods to an urban government context; and (3) some detailed experimental analysis involving specific elements of PPBS methodology, such as program-element formulation and cost-effectiveness analysis.

The first phase was essentially completed during the summer of 1966. The literature in budget determination, programming and planning, and cost-effectiveness methodology was surveyed with an eye to its application to urban problems. This phase will result in a working review paper which is now nearing completion.

The work in phase two has been only partially completed. To some extent it has been attacked through the literature survey and reports mentioned above. However, it has not been possible to develop the kind of information originally envisaged through contact with other groups involved in the application of PPBS at the urban scale, to come to very new or interesting conclusions.

Phase three, the application of these ideas to problems in Oakland is now beginning. Following discussions with the City Manager of Oakland and the Chairman of the Library Commission, we have decided to concentrate our efforts upon a single public service, the library system. This selection will allow us to go relatively deeply into the problems of definition of output and measurement of effectiveness, and hopefully also to build a first approximation of a cost model for the system. We will be constrained in the degree to which we are able to treat the question of the suitability of the selected organization for the definition of broad missions in local government. However, we do not feel that the municipal government in Oakland is either ready or capable at this point of a complete shift to a PPBS system. There is evidence that considerable payoff may be expected from rationalization of operations within departments, and among the departments the library operations appear to be especially in need of a hard look. A preliminary scan of available data suggests that by measures, such as cost per book circulated and circulation per thousand population, the Oakland Public Library performs poorly in comparison to other California cities. No administrative reorganization has taken place in the system for many years. There seems to have been little consideration of the function which it is supposed to perform for the city during a period when the city's population structure and needs have radically changed. Our intent is to examine the system from the perspective of its outputs of services to the population of the city. We shall attempt to identify and quantify classes of output, hopefully disaggregated by recipient groups. For these outputs we will identify measures of effectiveness and attempt, through the medium of a simple cost model, to relate output to cost. Given the relatively static nature of the library budget, we will assume a goal of maximizing effectiveness for a fixed or slowly rising over all cost.

The results of this effort should be an important step towards the establishment of a wider PPBS structure for the city. Together with outputs of the police and fire studies, it should give us the kinds of information about cost and social and spatial distribution of services that would be necessary for specification of the administrative and operational requirements of such a structure. We expect to have it substantially completed by early summer, 1967.

## 4. TECHNOLOGICAL TRANSFERENCE

### The Problem

This section of the project, conducted by H. Rittel and B. Ynzenga with the cooperation of R. Archibald, deals with the problem of transferring knowledge from one field to another. The project was originally intended to concentrate on designing logico-linguistic procedures through which solutions to problems might be found in fields that are not normally associated with those problems. The initial formulation suggested that, through successive transformations of problem statements pertaining to Area A (i.e., the city) one could enhance the probabilities that solutions could be found from within the repertoire of Area B (e.g., NASA-sponsored technology). The rationale held that each problem area corresponds to a certain discourse system, and thus the problem of search for transfers was mainly one of providing proper conceptual "bridges" between donor and recipient areas. This problem statement has been modified and expanded, in response to two major observations:

1. Urban problems, or problems existing in an urban context, are seldom well-defined, consistent, and clear. They seldom lend themselves to straightforward, one-to-one technological transferences.

2. The organization of the present NASA-documentation services does not allow for such a direct approach.

The main difficulty lies in the identification and formulation of the problem itself, rather than in its direct solution.

At present the objectives of the study are as follows:

1. To study and to model the processes of problem identification and formulation. More specifically, to construct a model that would confront the following questions:

   How can a problem be conceived? What are necessary and sufficient conditions for a problem to exist?

a) How does a problem change when the boundary of the system of which it is considered a part is modified or when the subsystems in terms of which it is studied are redefined?

b) How do different causal explanations of the same symptoms lead to different problem formulations and, therefore, solutions?

c) How does the level and the generality of problem formulation affect the possibility of innovations? When and how can a given problem be disaggregated into a collection of sub-problems?

d) When and how can a collection of problems be grouped into a more comprehensive problem statement?

e) How can stopping rules for problem refinements be designed?

The model must also deal with the difficulties of "implementing a problem," i.e., getting it accepted on an institution's "agenda" of projects. Ways must also be found for anticipating difficulties born from attempts to implement an eventual solution.

1. To study and to model ways of organizing a "body of knowledge" (e.g., the NASA files and their use), so as to support and facilitate both the tasks of identifying and modifying problem statements and the task of searching for solutions. Such an organization of a "body of knowledge" requires three distinct subtasks:

   a) To construct descriptive systems for the representation of recorded knowledge. (A common practice, for example, is to characterize documents by strings of descriptive terms and to couple them with document accession numbers, as done in the NASA filing system.) We are investigating the extent to which syntactical connections can be built into such a descriptive system.

b) To construct a relational structure among the descriptors which would represent different types of relationships among the concepts represented by these descriptors. Such a structure would, among other things, make it possible to obtain "common generalizations" of two or more descriptors and to resolve one descriptor into more specific descriptors. This would facilitate the process of problem refinement and the search for solutions.

c) As a further step, to establish networks of relationships among the described items (e.g., among documents in the NASA files). These could be interpreted as cross-referencing systems: once a problem solution is found, it would be possible to obtain immediately a set of related items of knowledge.

3. Based upon the models of problem formulation and using such relational structures, to study and to model strategies by which answers to given problem formulations could be searched for. This involves two efforts:

   a) To design search strategies which would call up from an initial problem formulation "relevant" knowledge from the system.

   b) To design routines which would lead to alternative paths of problem refinement. This would imply active interaction between the searcher and the retrieval system.

4. To develop a set of basic attributes for institutionalized innovation systems, in particular for urban innovation systems. This part of the project is concerned with:

   a) Conditions and motivations leading to the establishment of such urban innovation systems;

b) Outlining tasks to be fulfilled by such a system; and,

c) Discussing formal organizational alternatives under which those tasks could be carried on.

The NASA Files

At present, the various NASA documents are extracted by their authors or by an abstracting service. For various reasons, however, this abstracting service is not controlled by rigorous formal rules. Each document and its abstract is given an accession number. The abstracts are published in several periodical services (I.A.A., S.T.A.R., etc.). At present, on the average about 15 terms, based on the original document, are selected, which are assumed to provide a representative profile of the content of the document. The selection of these descriptor terms does not follow formal rules. The totality of these terms does not form a closed thesaurus of admissible terms. The dictionary, now containing more than 13,000 terms, is expanded monthly. Magnetic tapes are generated which contain the sequence of accession numbers, each followed by the bibliographic data and the sets of descriptive terms characterizing that document. Subscribers to the system frequently use inverted tapes, i.e., another tape on which every descriptor is followed by a list of the accession numbers of those documents in which the descriptor appears. A search task is formulated as a Boolean expression of up to 9 descriptors. The search problem consists of obtaining the subset of those accession numbers that satisfy this Boolean expression.

This system can be of limited usefulness only, even for clearly identified problems. First of all, nothing resembling a syntactical structure is imposed on the string of descriptors attached to each document. So, for example, documents related to "computer for design" and documents related to "design of computers" will have similar profiles. Second, in constructing a search profile, the system does not provide much help, because the relationships between the descriptor terms are not represented in it. For example, the system does not "know" that a "gyroscope" can be a part of a "guidance system,"

or that "iron" is a "metal." Therefore, this knowledge has to be spelled out by the user when he formulates his research profile. But, in the urban technology project, the motivation in using such a system is just the desire to search in an area where not much is known. The present installations of the dissemination system rely heavily on specialists who are familiar with the content of a certain "slice" of the data bank. They, however, are not very familiar with the user's problem area which, in the case of very innovative transfers, will be very remote from the search area. For this reason most successful transfers of space-generated knowledge have been straightforward modifications of the original hardware or technologies ("moon walker" into "wheel-chair substitute," "electrodes on astronauts" into "electrodes on playing children," "heat-resisting materials for re-entry" into "heat-resisting material for ovenware," etc.). In most of these cases the transfer took place starting from a given device or solution and then searching for a problem area to which the solution could be applied--not vice versa.

For innovation in urban systems, such an approach is not likely to produce as good results. First, the level of description at which urban problems are formulated is far more general and far less determined than that in manufacturing, for example. Besides, any meaningful urban innovative system must recognize difficult "problem-complexes" to be solved, and it must work from them towards "solution-complexes" rather than limit itself to finding problems for given piecemeal solutions.

## Urban Problems

Our perceptions of the difficulties in identifying and formulating urban problems rest on the following observations:

1. Owing to sparse knowledge about the working of urban systems, a given symptom of malfunction can be causally explained in many, and even contradictory, ways, each of them leading to entirely different problem statements. Thus, vandalism, neglect, anomie, deprivation, and numerous forms of misbehavior, as well as bad design,

defect in manufacture, or bad maintenance can all be used as causal explanations of the deterioration of public facilities.

2. The decision structure of the system--even within public institutions--is characterized by a multiplicity of decision-making units, whose images, perceptions, motivations, and criteria differ widely and even conflict among themselves. Thus, a given "phenomenon," even if equally perceived by all from the same empirical evidence, may produce entirely different problem formulations, depending on which government unit, profession, or institution formulates the problem.

3. Urban systems are characterized by their openness. In addition, they have no clear boundaries and no clearly separable subsystems of the sort that characterize private corporations. Nevertheless, for each problem an upper and a lower boundary must be defined--a task that may prove to be more burdensome and important than is typically recognized. For example, if action is to be taken, we need to identify clearly which components have to be included and how detailed a description of the components may be considered sufficient. A simple example of this is the problem of easier, faster, and safer access from fire stations to the scene of a fire. This problem could be formulated as a need for better and faster fire engines. It could, and perhaps should be, expanded so as to cover changes in the fire-alarm systems, improved design requirements for streets, and/or improved building accessibility. It could also be expanded towards a better system of traffic-light controls, or it could be raised to the level of more appropriate locational models for the placement of fire stations, taking into account the physical structure and activity patterns of the areas to be covered. And so on.

4. For similar reasons, if innovations take place on the level of small subsystems, such as technical gadgets, the possibility of achieving more important innovations on a higher level may be neglected. In other words, the strategy or the ideology that small improvements are better than no improvements may prove quite harmful. For example, improving the fire hose may preempt the motivation and the possibility of investing in different fire-fighting technologies for which hoses and hydrants may not be required at all.

5. Given that, for the most part, urban problems are defined in highly interconnected systems, the problem statement must account for consequences and after-effects in remote parts of the system and even outside the system. For instance, the introduction of high-powered detergents that could not be biologically decomposed destroyed the ecological equilibrium in water streams, and covered rivers with thick layers of stable foam, side-effects that had not been anticipated when household detergents were first distributed on the market.

Present Status and Expected Results of the Project

In pursuing our work towards the development of a theory of transfer, we have come upon some ideas for improving the NASA files, ideas which we will present to the technological utilization officials within NASA itself. In addition, as they are completed, we will be forwarding chapters of our theoretical monograph, which presents the conceptual basis underlying our suggestions.

Regarding the proposal for changes in the NASA system, the status of our work and our plans for future action are as follows:

1. We have analyzed the actual machine systems as well as the managing systems presently used in the Technology Utilization Program. As a basis for comparison, we have studied services and systems that confront problems similar to those we face, such as the United States Patent

Office and the indexing and abstracting services of the American Chemical Society.

2. We have generated formal paradigms for refining and expanding the uses of the NASA tapes and information systems. At a first level, these refinements would not require any changes of the present tapes, but would concentrate on the generation and use of new tapes extracted from the present ones. A formalism has been developed which makes it possible to construct matrices relating terms with each other and, respectively, documents with each other according to various relational criteria. These matrices are based on the entire inventory of documents and make use of the entire machine-term index. However, the same descriptor-descriptor matrix can, in some cases, be reconstructed from a selected inventory of documents. Similarly, the document-document matrix could be reconstructed from a selected list of descriptors.

   Those matrices can help the problem formulator to refine the search tasks and to identify more relevant documents. Means by which this can take place have been studied and modeled. Also, it is possible to prepare problem formulations on the basis of shorter but selected descriptor lists, and to carry out search tasks either within the shorter inventory of documents or based upon a sample of the total set of documents. If the present tapes and the ways in which descriptive terms are coupled with accession numbers were to fulfill the assumptions underlying this formal system, faster, more diversified, and more efficient use of the system would, it seems, be possible. The existence of condensed inventories of documents and descriptors may also simplify the task of updating the system every time an inflow of new documents takes place. Updating operations have been investigated, and we find that

proposals for modifications in the relational structure of terms or of documents may require the intervention of outside verifiers. As yet, we have not attempted a definite computer programming or test, nor do we expect to carry on the involved computer programming operations that a full-scale test would require. We shall limit ourselves to testing the hypothesis and the feasibility of our models on the basis of a small sample of the NASA files.

3. We have also developed recommendations for more extensive changes in the present system which will re-structure and expand the content of the present tapes without having to reprocess past documents; these involve new ways of generating future abstracts. The new abstracting service would be made compatible with the old one so that the present services of the system can be continued, although many of the improvements would be relevant only for the new inflow of documents. These recommendations propose the introduction of syntactical connections between different descriptors. We are now investigating several systems by which these syntactical connections could be incorporated. All those operations and refinements proposed under B are also a necessary part of these kinds of systems.

4. Finally, if complete revision proves to be possible, we will attempt to develop proposals for the design of alternative retrieval systems. The conversion of the present NASA system into one of those alternative systems would require a reprocessing of the entire inventory of documents. Such suggestions would then be considered as proposals for the organization of future information services whenever they occur.

5. We hope to develop recommendations for reorganizing the noncomputerized services involved in the technology utilization program.

One of the major difficulties we encountered when proceeding with our work came from the fact that little, if any, theoretical work had been published about how to utilize accumulated knowledge for attempting to solve practical problems. Therefore, we had to engage in constructing a theory upon which specific proposals could be built. Our preliminary formulation has already proved quite useful for describing and comparing a wide range of diversified situations in problem solving. For example, when analyzing case studies of innovative transfers, our theory helped to describe the processes at work and explained most of the difficulties encountered when attempting to implement innovative solutions.

We have considered it desirable to produce a monograph that will present in greater detail our conceptual constructs and generalized formal models. The applicability of the theory itself extends to problems of planning and innovation beyond the scope of the NASA project.

The monograph will be organized into four major parts. The first part has to do with the general area of problem finding, problem refinement and problem modification, definition of boundaries, and the selection of subproblems.

The second part deals with description, representation, organization, and use of the relational structures of knowledge. Depending on the type of relations, different types of conceptual bridges and conceptual chains are investigated.

The third part is involved with the general theory of transfer. In this part, the interaction between the "system of knowledge" and the formulation of the problem and its refinement are investigated. We place special emphasis on the "dialogue" by which the problem formulation is modified and on the changes that may take place in the problem context when relevant knowledge is activated and made available.

Finally, the fourth part deals with the social aspects of innovative processes, with implementation problems, with problems of after-effects, with clarification of conflict situations, with the possibility of arriving at compromises when apparently conflicting solutions arise, and with the design of innovative systems such as those that would be necessary in the city.

The material will be presented in two ways. First, it will be discussed in nontechnical language, and it will be organized and presented so as to reach a larger audience. Second, the same material will be discussed in logico-mathematical terms, together with a more rigorous and specialized discussion.

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